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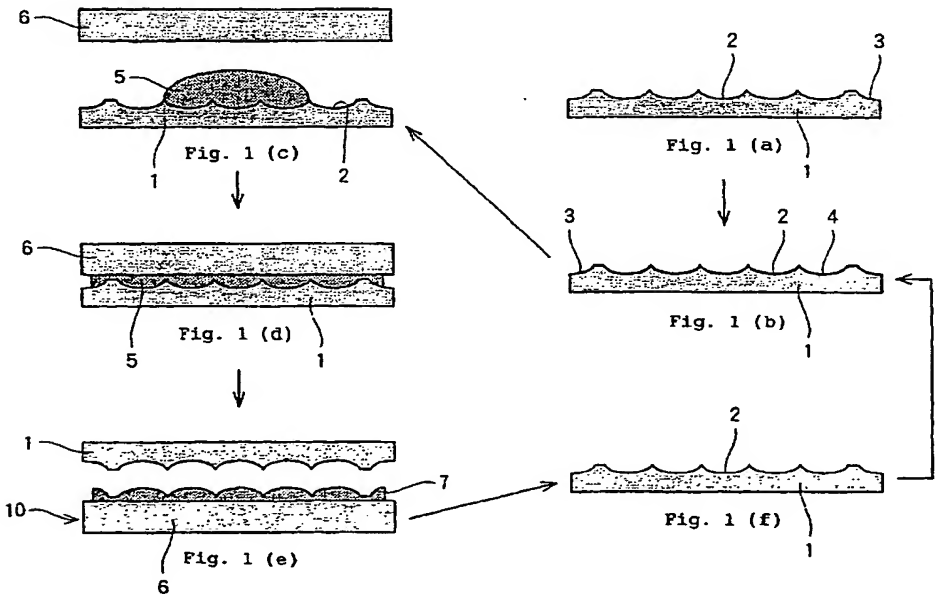
(54) Stamper for use in forming planar micro-lens array and method of forming thereof

(57) For providing a stamper for forming a planar micro-lens array, a stamper is prepared by forming plural concave portions (2) for forming lens portion upon a stamping surface thereof, and a trap portion (3) is provided surrounding said plural concave portions and continuing until an outer edge thereof. Then, onto the stamping surface, on which a release agent (4) is applied, there is applied a high refractive index resin (5), and a glass substrate (6) is pressed onto the high refractive index resin (5) to exude it. With this operation, the high refractive index resin (5) is filled into each of the plural concave portions (2), and any excess is received or accommodated in the trap portion (3), thereby preventing excess resin from being forced outside.



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Description

[0001] The present invention relates to a stamper for use in forming a large number of convex lens comprising resin having a high refractive index upon a surface of glass substrate, and also to a method for producing a plate-like micro-lens array by use of the stamper.

[0002] A flat-type or plate-like (planar) micro-lens array is installed into, for example, a part of a liquid crystal display element. Explaining a structure of such a liquid crystal display element by referring to Fig. 7, a gap is formed between glass substrates 101 and 102 by a spacer 103, into which liquid crystal 104 is poured. On a surface of the glass substrate 101 there are formed opposing electrodes 101a at the side of the liquid crystal 104, and on a surface of the other glass substrate 102 there are formed transparent pixel electrodes 102a at the side of the liquid crystal 104. Further, additional portions other than the transparent pixel electrodes 102a are formed which are not transparent, such as wiring, TFTs (thin film transistors), etc.

[0003] Next, upon an exterior surface of the glass substrate 101 there is bonded a planar micro-lens array 105, serving to focus irradiated light through the lens portion 106 thereof into pixel electrodes (i.e., openings for the pixels) 102a, so as to increase the brightness of an image projected upon the screen. Note that the pixels and lenses (lens elements) are provided in plural numbers.

[0004] An example of the method for producing such a planar micro-lens array 105 will be explained by referring to Fig. 8 attached.

[0005] First, recessed portions 111 are formed on the surface of the glass substrate 110 through an etching process, and then a resin of high refractive index 112 is applied thereupon and is spread over the surface of the glass substrate 110 by a stamper 113 so as to fill in plural recessed portions 111. Next, the high refractive index resin 112 is cured under light, thereby obtaining the lens portion 106 mentioned above.

[0006] However, in the case of producing or forming the planar micro-lens array with the method mentioned above, any of the high refractive index resin that is excess is pushed or forced out from the edge of the glass substrate and is cured during the curing process. As a result, the planar micro-lens array itself becomes larger in dimension thereof, such that it cannot be bonded or attached on the other element(s) and its size does not fit with the other portions for installation therewith. This is a disadvantage. Further, if the high refractive index resin exudes to the reverse of the substrate, the planar micro-lens array will experience degraded performance.

[0007] Furthermore, when a plurality of planar micro-lens arrays are cut out from a large-sized glass substrate on which multiple surfaces are formed, since the high refractive index resin forms a layer applied over the entire surface of the glass substrate, the layer of the high refractive index resin might be easily separated or exfoliated therefrom, or the surface of the micro-lens array may be damaged during a subsequent cutting procedure.

[0008] Therefore, the applicant of the present application already proposed a structure, disclosed in Japanese Patent Application No. Hei-7244288 (1995), in which a gutter portion 113 is formed surrounding the outside of the recessed portions 111 so as to receive or accommodate any high refractive index resin that exudes in excess therefrom, as shown in Fig. 9.

[0009] However, a problem lying in the method shown in Japanese Patent Application No. Hei-7244288 (1995) is that since the etching is performed on the glass substrate itself forming the planar micro-lens array, the etching must be performed on the glass substrate every time before applying the high refractive index resin thereon.

[0010] Further, as shown in Fig. 9, the gutter portion 113 is formed at the same time that the recessed portions 111 are formed by the etching, and therefore the depth of it comes to be same to those of the recessed portions 111. As a result, there is a possibility that the gutter portion 113 will have insufficient volume, though it may still be partially adequate. Nonetheless, any excess high refractive index resin cannot be accommodated or received therein with certainty.

[0011] According to a first aspect of the present invention, there is provided a stamper for use in forming a planar micro-lens array on a glass substrate, said array being formed from resin having a high refractive index which is pressed between a stamping surface of the stamper and a surface of the glass substrate to mold a plurality of convex lens-element portions, characterised in that said stamping surface of said stamper is provided with an array of concave portions to mold the plurality of convex lens-element portions.

[0012] Preferably the stamping surface of the stamper is provided with a trap portion for excess resin at the periphery of the array of concave portions. Preferably the trap portion has a depth substantially equal to that of the concave portions and is preferably formed around the whole periphery of the array of concave portions. In a further preferred embodiment, the stamping surface is provided with a plurality of separate arrays of concave portions corresponding to a plurality of micro-lens arrays.

[0013] According to a second aspect of the present invention, there is provided a method of forming a planar micro-lens array by use of a stamper, the array comprising a plurality of convex portions of a high refractive index resin arranged on the surface of a glass substrate, said method comprising the steps of:

providing a stamper having concave portions formed in a stamping surface, the stamper being arranged so that the stamping surface faces upwardly and being provided with a release agent on the stamping surface;

applying high refractive index resin upon the stamp-

ing surface of said stamper;
pressing a glass substrate upon the resin to mold the resin into the concave portions;
curing the resin to form the lens portions of said micro-lens array; and
releasing the stamper to leave the planar micro-lens array formed on said glass substrate.

[0014] In one preferred embodiment of the present invention, there is provided a stamper for use in forming a planar micro-lens array, comprising a plurality of convex high refractive resin portions for forming lenses, which is applied onto a planar surface of a glass substrate, in which, after the high refractive resin material is applied to plural concave portions of said stamper, the planar glass substrate is contacted thereon to exude the resin in between the concave portions and the glass plate, and is cured and separated therefrom, wherein the plurality of concave portions for forming lenses of said micro-lens array are formed on a stamping surface of said stamper by transcription or etching, and in that a trap portion is formed at an outer periphery of the lens of said stamping surface of said stamper by transcription or etching, with a depth substantially equal to that of said concave portions, continuing at least until an outside edge of a region where said glass substrate is to be contacted therewith.

[0015] With the construction according to the preferred embodiments, the trap portion can be formed large enough to effectively prevent any excess high refractive index material from being pushed or forced out.

[0016] Preferably, the stamper is formed with laminated layers of nickel, which are formed by performing an electro-forming process upon a surface of a master plate of said micro-lens array (transcription), or alternatively, after forming a plurality of small concave portions upon a surface of a glass plate as a model for said stamper by wet etching, a reverse mold is formed with laminated layers of nickel, which are formed by performing the electro-forming process upon the surface of the glass substrate having the plural concave portions, and then said stamper is formed with laminated layers of nickel by performing the electro-forming process upon the surface of the reverse mold having the plural convex portions thereon, or said stamper is formed with a glass substrate, upon a surface of which there are directly formed a large number of concave portions by a wet etching process.

[0017] Further, according to the present invention, in the stamper, wherein in the stamping surface of said stamper there are formed plural groups of concave portions, corresponding to plural planar micro-lens arrays, each being separate, said trap portion is formed at each outside periphery of each group of the concave portions for each planar micro-lens array, with the depth substantially equal to that of said concave portions.

[0018] Moreover, according to a further preferred embodiment of the present invention, there is provided a method for forming a planar micro-lens array by use of the stamper as defined above, comprising the steps of:

turning a stamping surface of said stamper upward, upon which surface is applied a release agent;

applying high refractive resin material upon the stamping surface of said stamper;

pressing a glass substrate upon the high refractive resin material to exude the high refractive resin material into the concave portions and then curing the high refractive resin material to form the lens portions and thereafter;

releasing the stamper to leave the planar micro-lens array formed on said glass surface; and

again applying the release agent upon a molding surface of said stamper after the release thereof, in preparation for a subsequent process.

[0019] With the steps mentioned above, since the etching must be performed only when the stamper is produced, it is possible to greatly reduce the scale or the number of production processes, as well as to prevent any excess high refractive index resin from being forced out.

[0020] Here, as the glass substrate for forming the planar micro-lens array, there can be listed soda-lime glass, alkaline aluminosilicate glass, alkaline borosilicate glass, non-alkaline glass, crystallized glass, quartz glass, etc. In addition, those glass materials can be used as the material of the stamper.

[0021] Further, as the high refractive index material, there can be listed polyester resin, epoxy resin, silicon resin, phosphazene resin, phenol resin, polyimide resin, acryl resin, urethane resin, etc.

[0022] Further, the release agent to be applied upon the stamping surface of the stamper is appropriately a compound of fluorine group or a compound containing silicon group. Also, as an organic compound of the silicon group, preferably a resolvable one, which mainly contains polysiloxane, chlorsilane compound, alkoxysilane compound, disiloxane compound, and is resolvable into water soluble organic solvent, such as water or alcohol, or resolvable into hydrocarbon organic solvent or fluorine organic solvent, is used.

[0023] Further, those which contain fluorine in the organic compound of the silicon group are very low in surface tension at the release surface of the mold, and therefore, they exhibit good release qualities. Those can also be used in a mixture thereof.

[0024] Certain preferred embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figs. 1 (a) through (f) are views for explaining a forming method by use of a preferred stamper according to the present invention;

Figs. 2 (a) through (d) show a method for preparing the stamper;

Figs. 3 (a) through (e) show another embodiment of the method for preparing the stamper;

Figs. 4 (a) through (c) show plan views of a planar micro-lens array obtained according to preferred methods of the present invention;

Fig. 5 shows an embodiment in which a plurality of planar micro-lens arrays are formed by one stamper;

Fig. 6 shows a cross-section view of a liquid crystal display element comprising a planar micro-lens array prepared by a preferred method according to the present invention;

Fig. 7 shows a cross-section view of a conventional liquid crystal display element;

Fig. 8 is a view for explaining a conventional method for forming a planar micro-lens array; and

Fig. 9 shows a cross-section view of the a conventional planar micro-lens array.

[0025] Here, as shown in Figs. 1 (a) through (f) explaining the forming method by use of a stamper according to a preferred embodiment of the present invention, the stamper 1 is manufactured by means of an electro-forming or wet etching process, as shown in Fig. 1 (a). Upon a molding or stamping surface of this stamper 1 there is formed plural concave portions 2 for forming lens elements, and a trap portion 3 is formed all around the plural concave portions, continuing until an outer edge thereof. The depth of this trap portion 3 is substantially equal to those of the plural concave portions 2.

[0026] Here, an example of the method for preparing the stamper 1 will be explained on the basis of Figs. 2 (a) to (d) and Figs. 3 (a) to (e).

[0027] First, in the method shown in Figs. 2 (a) to (d), a layer of photo-sensitive film 31 is formed on a surface of a substrate 30, as show in Fig. 2 (a), and then, as shown in Fig. 2 (b), upon the photo-sensitive film 31 there is irradiated an electron beam to manufacture a master micro-lens array, in which convex portions 32a are formed for subsequently forming the lens elements 32 and the trap portion 3.

[0028] Next, as shown in Fig. 2 (c), a nickel layer 33 is laminated upon the surface of the master micro-lens array by means of an electro-forming method, and further, as shown in Fig. 2 (d), the laminated layer is later separated from the master micro-lens array thus obtaining a stamper 1.

[0029] Also, in another method shown in Figs. 3 (a) to (e), upon the surface of a glass substrate 40 serving as a model, as shown in Fig. 3 (a), a wet etching is performed through a mask 41, and as shown in Fig. 3 (b), plural minute concave portions 42 are formed having a spherical or cylindrical surface shape, together with a trap portion 43. Further, as shown in Fig. 3(c), the wet etching is again performed without the mask so as to form plural small concave portions closely arrayed next to each other and aligned with one another. Then, as shown in Fig. 3 (d), a nickel layer is laminated onto the surface, on which the plural concave portions are formed closely arrayed and aligned, by means of an electro-forming method, to form a reverse mold 44. Further, by again laminating the nickel layer upon the surface of this reverse mold 44 by means of the electro-forming method, the stamper 1 can be obtained.

[0030] However, the stamper 1 also can be manufactured with a glass substrate by the process shown in Figs. 3 (a) to (c).

[0031] When the stamper 1 is prepared in the manner mentioned above, a release agent 4 is applied onto the molding or stamping surface of the stamper 1, as shown in Fig. 1 (b). On the stamping surface, onto which the release agent 4 is applied, as shown in Fig. 1 (c), resin 5 having a high refractive index is applied. The high refractive index resin 5 can be of the light-curable type, which is cured by irradiation of UV (ultra violet) light, or of the heat-curable type, which is cured by applying heat thereto. Further, as shown in Fig. 1 (d), the glass substrate 6 is pressed onto the above-mentioned high refractive index resin 5 so as to exude it. However, it is preferable that a coupling agent be applied upon the surface of the glass substrate 6, which contacts with the high refractive index resin 5, in advance. As the coupling agent, there can be considered γ-glycidpropyl-trimethoxy silane or mercapt-propy-trimethoxy silane. Also, the viscosity of the high refractive index resin 5 appropriately lies from 0.1 to 100 poise (0.01 to 10 Pas), and it is effective to apply the resin under a reduced pressure condition in order to prevent creating bubbles therein.

[0032] By the operation mentioned above, the high refractive index resin 5 is filled into the plural concave portions 2, and at the same time, any excess high refractive index resin 5 is received into or accommodated by the trap portion 3, and is not disadvantageously forced outside.

[0033] When the high refractive index resin 5 is filled in the plural of concave portions 2, UV light is irradiated in order to harden the high refractive index resin 5 to form the lens elements 7.

[0034] Since, upon the stamping surface of the stamper 1 there is applied the release agent, while the coupling agent is applied upon the surface of the glass substrate 6 contacting with the high refractive index resin 5, the lens elements 7 are bonded onto the glass sub-

strate 6. Accordingly, as shown in Fig. 1 (e), when the stamper 1 is removed or separated, a planar micro-lens array 10 comprising the lens elements 7 on the glass substrate 6 can be obtained.

[0035] Moreover, the stamping surface of the stamper 1, after finishing the forming process, as shown in Fig. 1 (f), is washed, and the release agent is applied again onto the stamping surface for a subsequent forming operation. In this manner, by using the stamper 1 repeatedly, the etching process is necessary only when the first stamper 1 is manufactured, thereby reducing the complexity and cost of the manufacturing processes greatly.

[0036] Figs. 4 (a) to (c) show a plan view of the planar micro-lens arrays obtained according to preferred embodiments of the present invention, in particular, Fig. 4 (a) shows lenses of a hexagonal shape, Fig. 4 (b) a square shape, and Fig. 4 (c) a lenticular shape, respectively. All shapes shown may be easily attained according to the method of the present invention, and the invention may equally be applied to preparing lens arrays in other shapes.

[0037] Fig. 5 is a view for explaining an embodiment in which plural planar micro-lens arrays are formed by means of a single stamper, wherein the high refractive index resin 5 is applied into each of the plural concave portions 2 of the stamper 1, and plural glass substrates 6 are placed onto the high refractive index resin 5, one by one.

[0038] However, not shown in the figure, with the stamper shown in Fig. 5, it is also possible to obtain production of plural planar micro-lens arrays on a large-sized glass substrate, each of which is cut out therefrom afterward.

[0039] Fig. 6 shows a liquid crystal display element, to which is applied the planar micro-lens array 10 obtained in the manner mentioned above. The liquid crystal display element 20 defines a cell by bonding the glass substrate 21 onto a glass substrate 22 through a spacer 23, and on the glass substrate 22 forming cells there is contacted a lens-forming surface comprising the planar micro-lens array 10 through a low refractive index material 24, such as a fluorine group resin, acrylic resin group or epoxy resin group, etc. Thereafter, liquid crystal 25 is filled inside the space defined between the glass substrate 21 and the glass substrate 22, so as to complete the liquid crystal display element 20.

[0040] Further, on the surface of the glass substrate 21 or 22, at the side of the liquid crystal 25, there are previously formed opposing electrodes 26, while pixel electrodes 27 are formed on the surface of the glass substrate 21 at the side of the liquid crystal 25.

[0041] As is fully explained above, in accordance with the present invention, there is no necessity to treat the glass substrate to be the micro-lens array with an etching process during each time when forming thereof, thereby greatly simplifying the process of production thereof.

[0042] Further, since the trap portion is formed all around the stamper, continuing until the outer edge thereof, any excess high refractive index resin will not be forced out during the forming process. And, since any excess high refractive index resin will not be disadvantageously forced out, the high refractive index resin coating film will not be torn or damaged when cutting plural lens arrays from a large glass substrate. Also, when forming a planar micro-lens array on a glass substrate using the method according to the invention, it is easy to insert a jig between the glass substrate and the stamper. Therefore, the manufacturing processes for producing the planar micro-lens array(s) becomes easy, and any possibility that the glass substrate and/or the stamper might be injured is significantly reduced.

Claims

1. A stamper for use in forming a planar micro-lens array on a glass substrate (6), said array (10) being formed from resin (5) having a high refractive index which is pressed between a stamping surface of the stamper (1) and a surface of the glass substrate to mold a plurality of convex lens-element portions (7), characterised in that said stamping surface of said stamper is provided with an array of concave portions (2) to mold the plurality of convex lens-element portions (7).

2. A stamper as claimed in claim 1, wherein said stamping surface of said stamper is provided with a trap portion (3) for excess resin at a periphery of said array of concave portions (2).

3. A stamper as claimed in claim 2, wherein said trap portion (3) has a depth substantially equal to that of said concave portions (2).

4. A stamper as claimed in any preceding claim, wherein said stamping surface of said stamper is provided with a plurality of separate arrays of concave portions (2) corresponding to a plurality of micro-lens arrays (10).

5. A method of forming a planar micro-lens array by use of a stamper, the array (10) comprising a plurality of convex portions (2) of a high refractive index resin arranged on the surface of a glass substrate (6), said method comprising the steps of:

   providing a stamper (1) having concave portions (2) formed in a stamping surface, the stamper being arranged so that the stamping surface faces upwardly and being provided with a release agent on the stamping surface;
   applying high refractive index resin (5) upon the stamping surface of said stamper (1);

pressing a glass substrate (6) upon the resin to mold the resin into the concave portions (2);
curing the resin to form the lens portions (7) of said micro-lens array; and
releasing the stamper (1) to leave the planar micro-lens array formed on said glass substrate.

6. A method as claimed in claim 5, wherein a release agent is applied on the stamping surface of said stamper after the release thereof, in preparation for a subsequent process.

7. A method as claimed in claim 5 or 6, wherein said stamper (1) has a plurality of arrays of concave portions (2) corresponding to a plurality of micro-lens arrays, and separate glass substrates, each corresponding to an array of concave portions, are pressed upon the high refractive index resin which has been applied to each of said arrays of concave portions, to form each of the micro-lens arrays.

8. A method as claimed in any of claims 5, 6 or 7, wherein said stamper (1) is provided by wet etching a glass substrate to form the concave portions (2).

9. A method as claimed in any of claims 5, 6 or 7, wherein said stamper (1) is provided by applying layers of nickel by an electro-forming process to a surface of a reverse mold (44).

10. A method as claimed in claim 9, wherein said reverse mold is formed by applying layers of nickel (44) by an electro-forming process to a surface of a glass substrate (40) which has been wet etched to form a plurality of concave portions (42) corresponding to the concave portions (2) of the stamper (1).

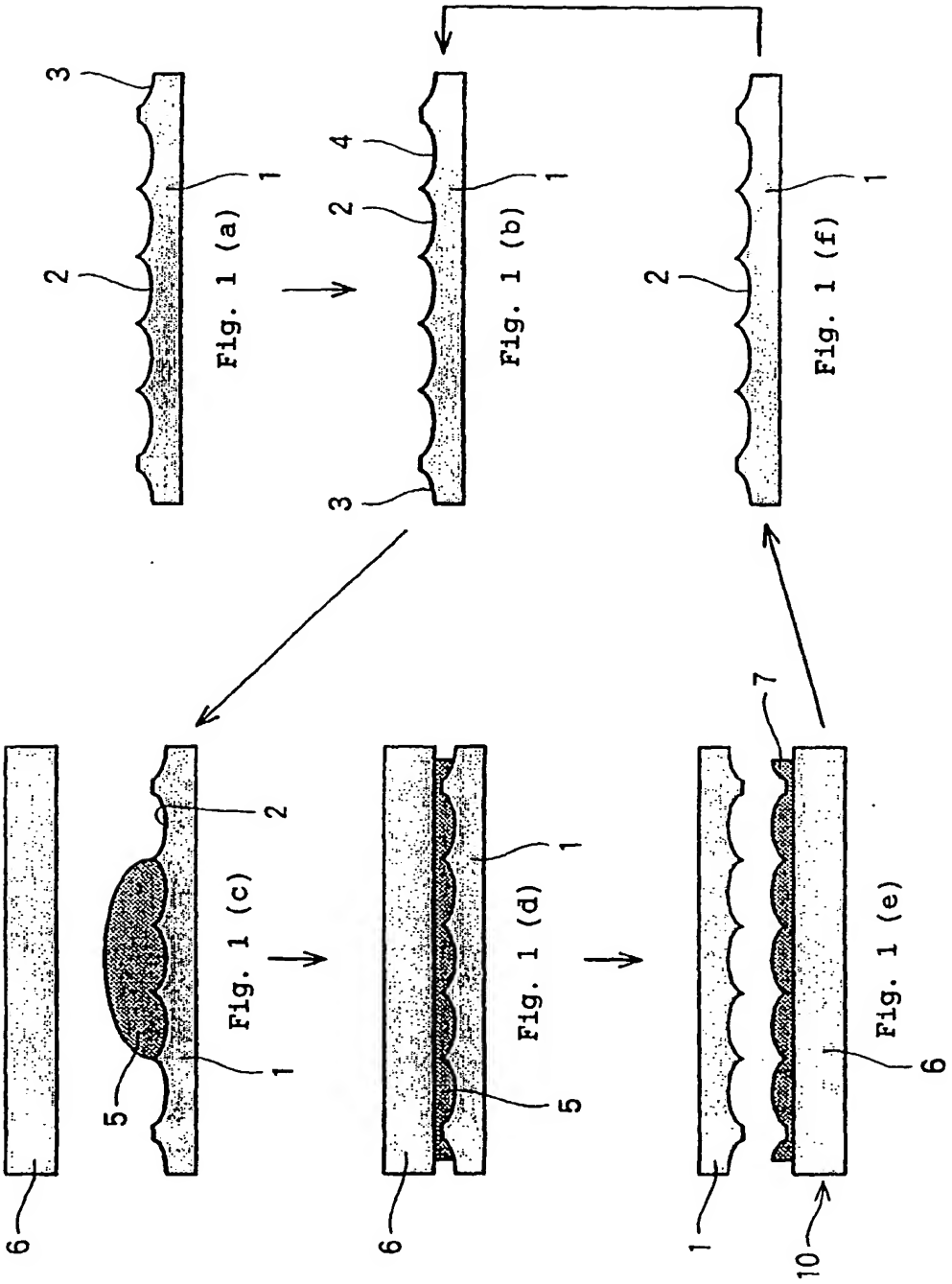

3
2
1
Fig. 1 (a)
4
2
1
3
Fig. 1 (b)
2
1
Fig. 1 (f)
2
1
5
6
Fig. 1 (c)
1
5
6
Fig. 1 (d)
7
6
1
10
Fig. 1 (e)

Fig. 2 (a)

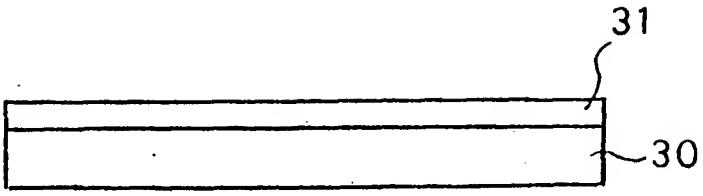


Fig. 2 (b)

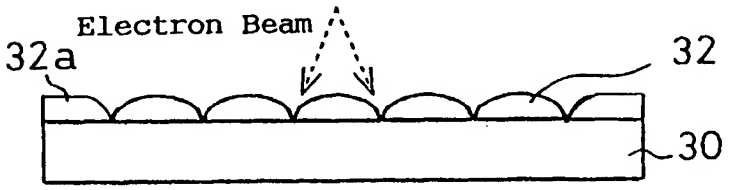


Fig. 2 (c)

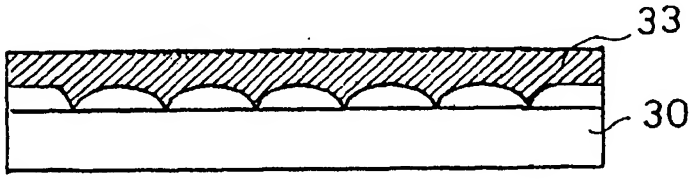


Fig. 2 (d)

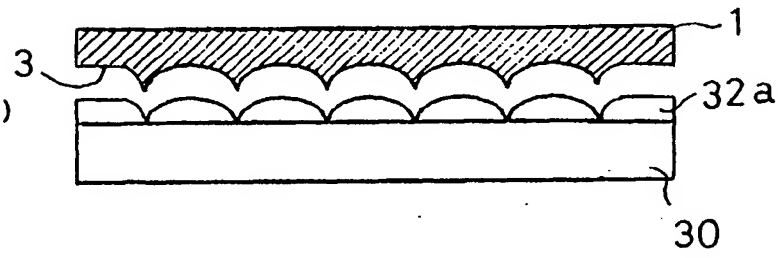


Fig. 3 (a)

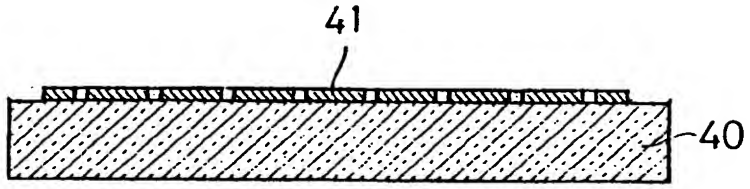


Fig. 3 (b)

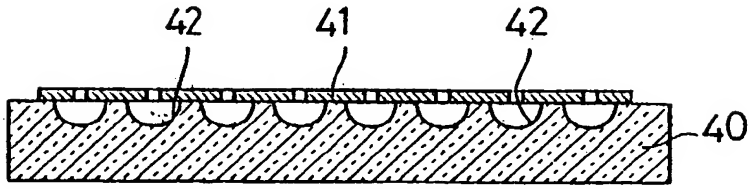


Fig. 3 (c)

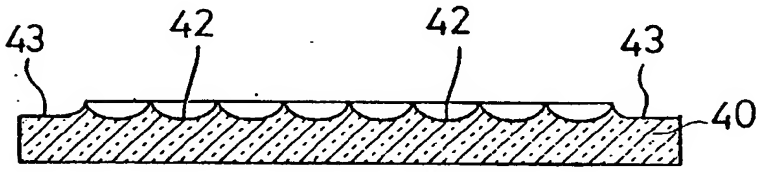


Fig. 3 (d)

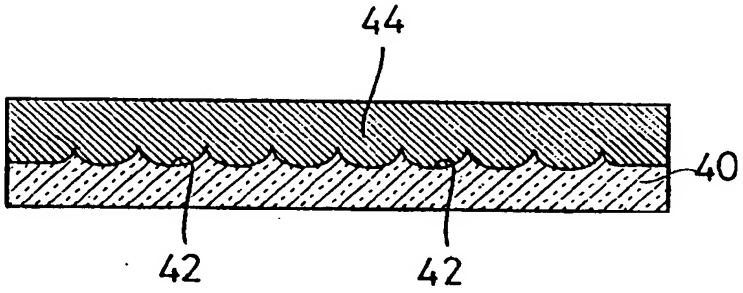


Fig. 3 (e)

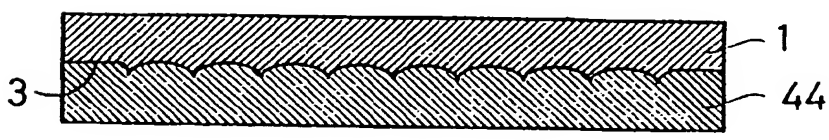


Fig. 4 (a)

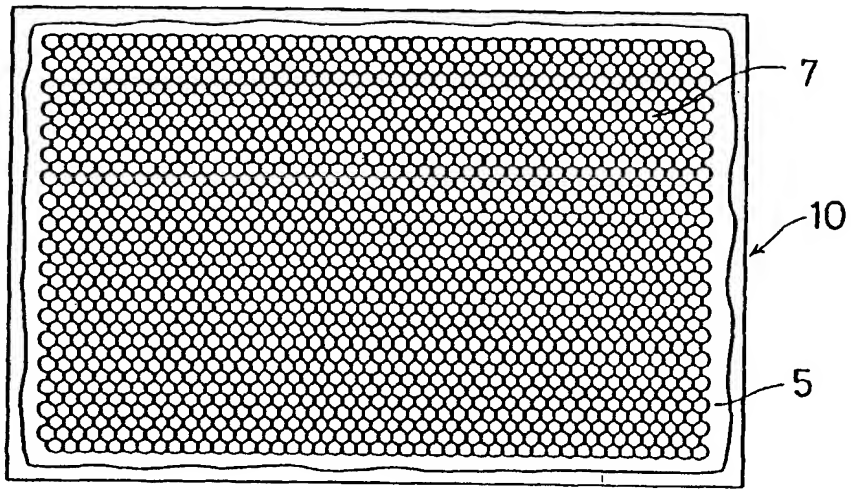


Fig. 4 (b)

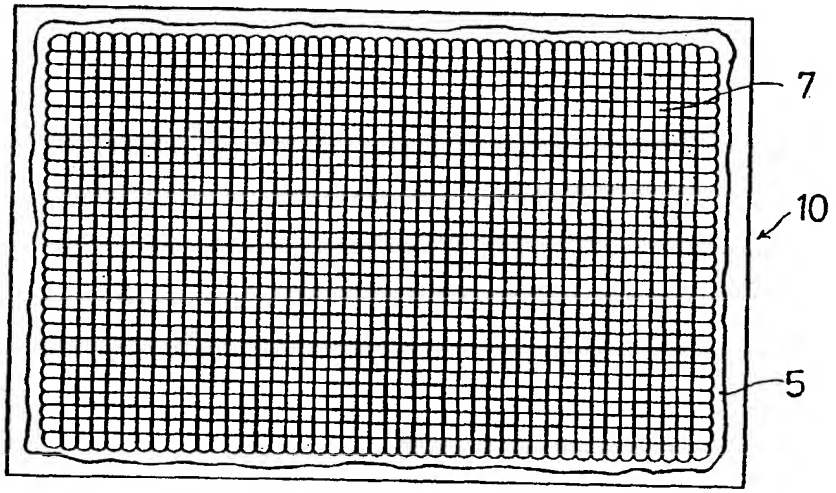
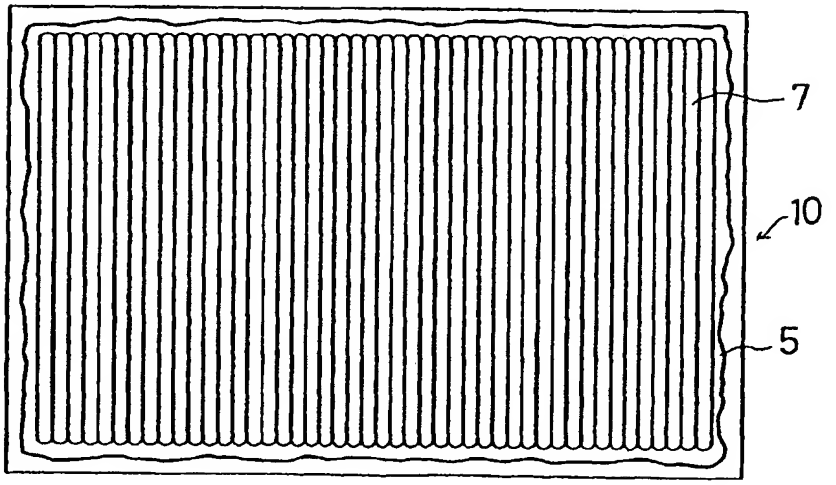


Fig. 4 (c)



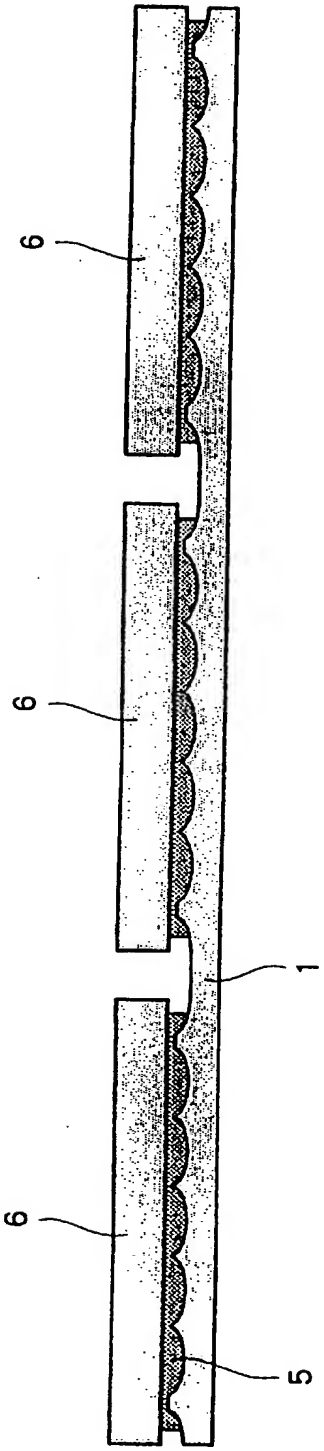


Fig. 5

Fig. 6

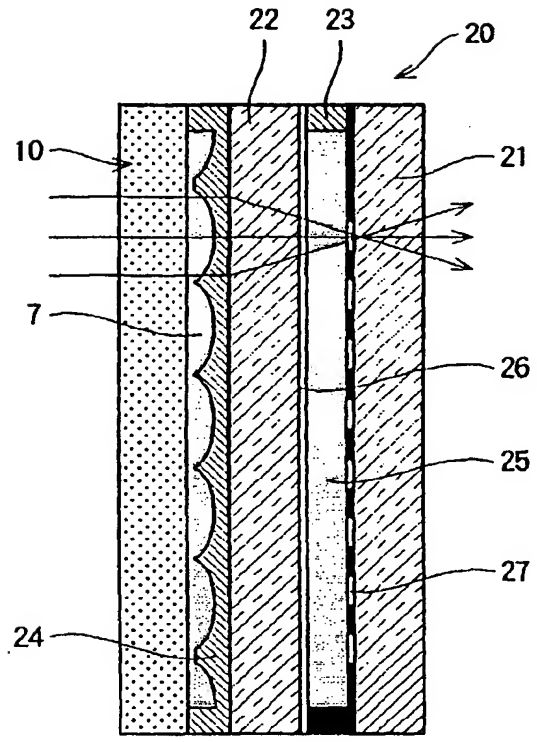


Fig. 7

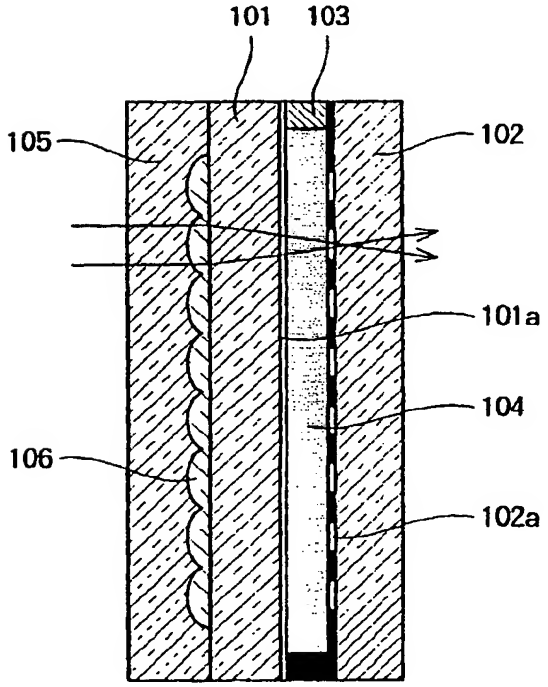


Fig. 8

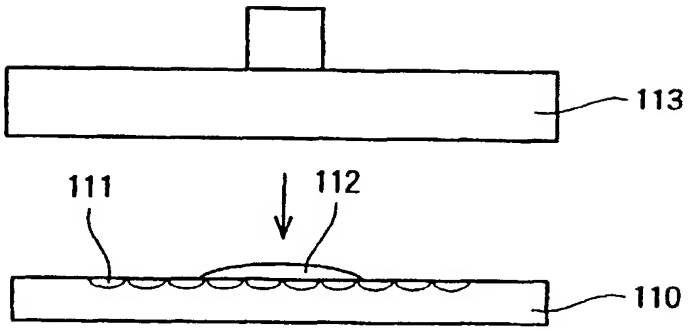
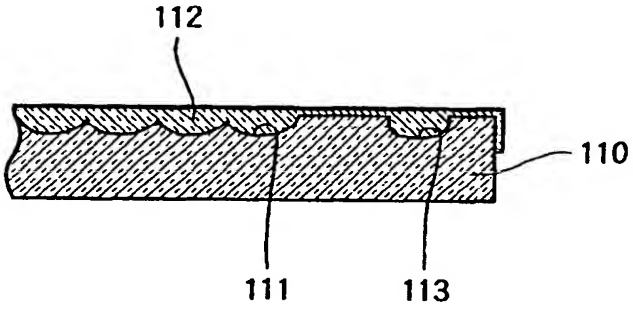


Fig. 9



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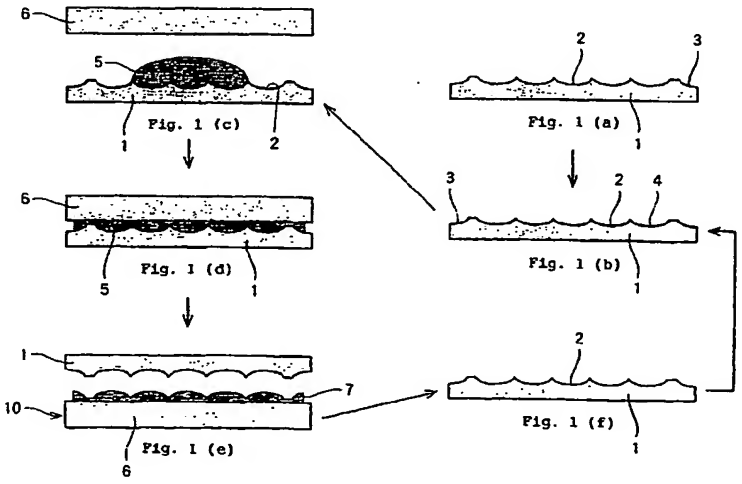
(54) Stamper for use in forming planar micro-lens array and method of forming thereof

(57) For providing a stamper for forming a planar micro-lens array, a stamper is prepared by forming plural concave portions (2) for forming lens portion upon a stamping surface thereof, and a trap portion (3) is provided surrounding said plural concave portions and continuing until an outer edge thereof. Then, onto the stamping surface, on which a release agent (4) is applied, there is applied a high refractive index resin (5), and a glass substrate (6) is pressed onto the high refractive index resin (5) to exude it. With this operation, the high refractive index resin (5) is filled into each of the plural concave portions (2), and any excess is received or accommodated in the trap portion (3), thereby preventing excess resin from being forced outside.



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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 8646

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X	EP 0 658 779 A (SHARP KK :OMRON TATEISI ELECTRONICS CO (JP)) 21 June 1995 (1995-06-21) * column 8, line 12 - line 25; figure 3 *	5,6,9	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 August 2001	Roberts, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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Application Number
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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

European Patent Office

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 98 30 8646

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-4

   A stamper for forming a planar micro-lens array which stamper comprises a trap section

2. Claim : 4

   A stamper for forming planar micro lens arrays which stamper comprises a plurality of separate arrays

3. Claims: 5-10

   Method for making a planar micro lens array which array comprises a glass substrate

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 8646

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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